JAPAN

EDICT OF GOVERNMENT

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JIS Z 9116 (1990) (English): Lighting of tunnels for motorrized traffic

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The citizens of a nation must honor the laws of the land.

Fukuzawa Yukichi

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JIS

JAPANESE INDUSTRIAL STANDARD

Lighting of Tunnels for Motorized Traffic

JIS Z 9116—1990

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In the event of any doubt arising,
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JAPANESE INDUSTRIAL STANDARD J I S

Lighting of Tunnels for Motorized Traffic Z 9116-1990

1. Scope

This Japanese Industrial Standard specifies the qualitative reference relating to the lighting of tunnels for roads provided mainly for motorized traffic, hereafter referred to as the "tunnel".

Remark: The qualitative reference defined in this Standard means the fundamental lighting technological conditions for lighting in tunnels and on the connected roads before and after the tunnel desirable to prepare for safe operation of motorcars taking into consideration the change of complex perceptive characteristic occurring in vision of operator of the motorcar to approach to, enter and pass through the tunnel and his psychological reaction and the environmental conditions proper to tunnel.

2. Definitions

For the main terms used in this Standard the definitions in JIS Z 8113 apply, and the rest of the terms shall be as follows:

(1) Terms Relating to Tunnels The terms relating to tunnels shall be as follows.

(a) design speed The speed of motorcar to be taken as base for design of road.

(b) traffic density Number of motorcars passing through a certain section of road in a defined period of time.

(c) construction limit Limit for securing space to prohibit the placing matters able to be obstacles in the range of a certain defined width and height to secure the safety of passage for motorcars and walkers on road.

(d) visual range Length of the top point of obstacle in height 10 cm on central line of concerned driveway able to get unobstructed view from the height 1.2 m on the central line of the driveway measured along the central line of the concerned driveway.

Applicable Standards:

JIS Z 8113-Glossary of Lighting Terms

JIS Z 9111-Lighting for Roads

(2) Terms Relating to Lighting The terms relating to lighting shall be as follows.

(a) road surface luminance The luminance of road surface near to the frontal steady gazed point seen in looking angle of declination 1 degree from the position of eyes of operator.

(b) luminance in access zone The mean luminance of visual field in vision angle 20 degrees taking the tunnel as center seen from the position of eyes of operation in front by visual range of the entrance of tunnel.

(c) continuous lighting The lighting facilities established continuously in a single road part of road except tunnel, bridge, etc.

(d) flickering The phenomenon sensed as nonstational stimulus in the case where the light from a series of light sources coming in sight in relatively little period.

(e) glare The visual perception generating discomfort or deteriorating visual function because of excessive luminance or excessive luminance contrast.

(f) array of lighting apparatus Method to array the lighting apparatus along the tunnel. As for this array, there are faced each other array, staggerd array, one-sided array, central array, etc.

(g) layout of lighting apparatus Method of layout for lighting apparatus determined by the mounting height, interval and array of lighting apparatus.

3. Items to Be Attended to in Plan of Tunnel Lighting

The items to be attended to in the plan of tunnel lighting shall be as follows.

(1) State of Visual Field Near Entrance The luminance of sky, artificial structures such as road surface, etc., natural features on the earth and slope near to the entrance in the visual field of operator of motorcar approaching to the tunnel and their occupying rate in the visual field.

(2) Conditions of Structures Shape of section of tunnel, total length, plane and longitudinal line shape of road in tunnel, surface state, reflectance, etc. of road surface, wall surface, ceiling surface.

(3) Traffic State The design speed, traffic density, passage method, mixing ratio of large-sized cars, etc.

(4) Ventilating State Existence of exhaust system, ventilating method, transmittance of air in tunnel, etc.

(5) Plan of Maintenance and Control Cleaning method, cleaning frequency, etc.

4. Requirements of Tunnel Lighting

4.1 Visuality of Operator The tunnel and connected roads before and behind the tunnel shall be equipped with lighting so that the operator of motorcar may discover the obstacles,etc. on road surface and may be given visibility sufficiently to avoid the danger of accidents.

4.2 Comfortableness of Operator The comfortableness of operator shall be as follows.

(1) Sense of Security at Time of Operation For the purpose of that the operator of motorcar may drive the motor car with feeling easy the state of road in front, it is desirable so that the road surface and wall surface may be illuminated clearly and in about uniform state in clarity.

(2) Discomfort at Time of Operation For the lighting facilities in tunnel, should not generate the glares giving the discomfort to operator of motorcar and also the light variation giving the discomfortable flicker to operator of motorcar due to the injecting light into travelling motorcar.

4.3 Securing of Inductivity and Lighting Conditions For the layout of lighting apparatus in the tunnel, illuminate the road surface and wall surface up to the sufficient luminance, and make the mounting height constant to the road surface, accord to the alignment of road, and make the motorcar operator judge accurately the alignment change of frontal road.

5. General Principle of Lighting Design

5.1 Construction of Tunnel Lighting

5.1.1 Functional Construction The tunnel lighting shall be constructed with the lighting set up in tunnel and the lighting set up in the connected roads before and behind the tunnel as given in Fig. 1.

The lighting to be set up in tunnel shall be constructed with fundamental lighting, entrance lighting and exit lighting according to their functions.

The lighting to be set up to connected roads before and behind the tunnel shall be constructed with lighting of entrance part connected road and lighting of exit part connected road according to their functions.

Remarks 1. The fundamental lighting means the lighting to secure nearly uniform luminance over the total length of tunnel to secure the visibility of operator in tunnel during day and night.

2. The entrance lighting means the lighting to be set up in addition to the fundamental lighting for the purpose to resolve the problem of visual sense near to tunnel entrance in day time. The entrance lighting consists of boundary part, transition part and relaxing part as shown in Fig. 2.

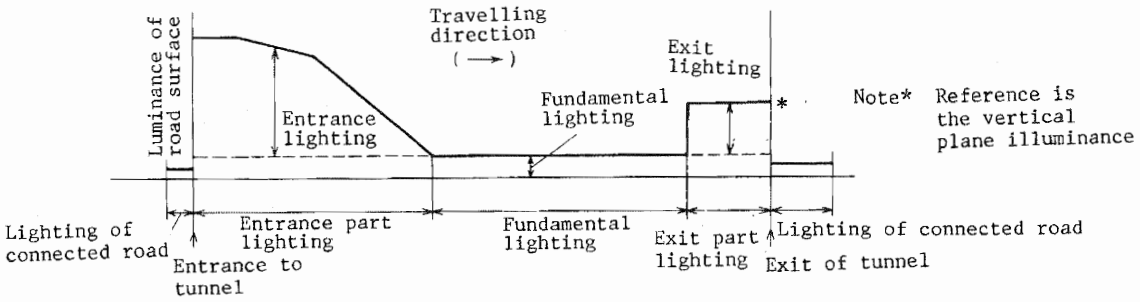
3. The exit lighting means the lighting to be set up in addition to fundamental lighting as necessary to resolve the problems of visual sense occurring by glare of high luminance in the access-Zone visible through the tunnel exit in daytime.

4. The lighting in entrance part connected road means the lighting to be set up in connected road of tunnel entrance part so that the state near to tunnel entrance in night, change of width of roads in and out of tunnel, etc. may be visible to the operator of motorcar.

5. The lighting in exit part connected road means the lighting to be set up in connected road of exit part so that the change of alignment of dark road connecting tunnel can be visible sufficiently beforehand from the inside of bright tunnel for the operator of motorcar approaching to tunnel exit in the night.

Fig. 1. Construction Tunnel Lighting

(a) Case of One-Way Traffic



(b) Case of Facing Traffic

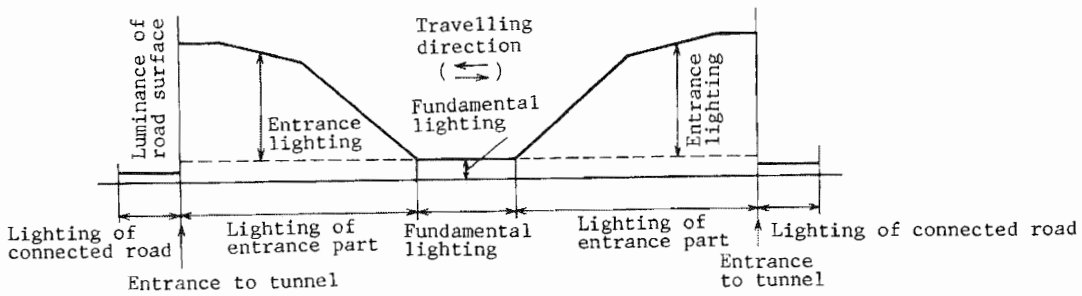
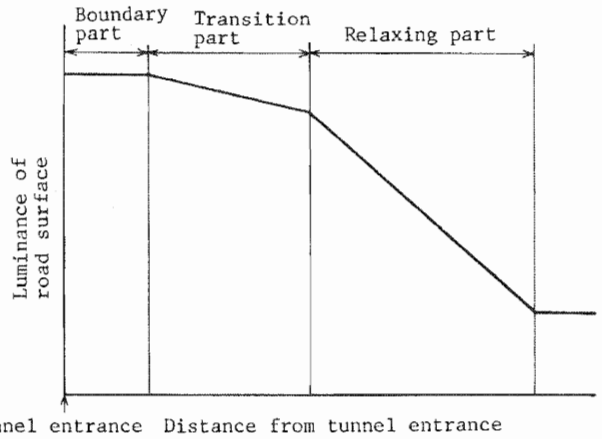


Fig. 2. Construction of Entrance Part Lighting



5.1.2 Sectional Construction of Lighting in Tunnel The lighting in tunnel shall be constructed by three sections of the entrance part lighting, fundamental lighting and exit part lighting as shown in Fig. 1.

Remarks 1. The entrance part lighting means the lighting of section where the entrance lighting has been set up and is constructed by fundamental lighting and entrance lighting.

2. The fundamental part lighting means, in the case where the tunnel is one-way traffic, the lighting between the terminal point of entrance lighting and the initial point of exit lighting (when the exit lighting does not exist, section up to tunnel exit), and, in the case where the tunnel is for facing traffic, means the lighting between terminal points of two entrance lightings and is constructed only by the fundamental lighting.

3. The exit part lighting means the lighting of section set up with exit lighting and is constructed by fundamental lighting and exit lighting.

5.2 Lamps and Lighting Apparatus Use the lamps whose effectiveness, light color, color rendering properties, life performance characteristic, ambient temperature characteristic, life, etc. suit the tunnel lighting and the lighting apparatus whose distribution of luminous intensity, glare control, utilization factor, structure, etc. suit the tunnel lighting.

5.3 Layout and Array of Lighting Apparatus For the layout and array of lighting apparatus, make the luminance distribution of both road surface and wall surface nearly uniform and do not generate flicker discomfortable to the operator of motorcar.

6. Reference of Tunnel Lighting

6.1 Fundamental Part Lighting The mean road surface luminance of fundamental part lighting shall be as given in Table 1 according to the design speed.

Table 1. Mean Road Surface Luminance of Fundamental Part Lighting

Design speed km/h	Mean road surface luminance cd/m^2
100	9.0
80	4.5
60	2.3
40	1.5

Remarks 1. In the case where the traffic density is large and the transmittance of air in tunnel is low, it is desirable to make the mean road surface luminance larger than these values.

2. In the case where the traffic density is small and the transmittance is high, the mean road surface luminance may be lower than these values.

3. The mean luminance of wall surface is desirable to be of values 1.5 times or over of mean road surface luminance.

Remark: In the night, these values may be decreased. However, the lowest value shall be 1.0 cd/m^2 in the case of design speed 80 km/h or over and 0.7 cd/m^2 in the case of design speed 60 km/h or under.

Further, in the case where continuous lightings are provided on the connected roads, the mean road surface luminance in the night, should preferably be the value two times or more the mean road surface luminance.

6.2 Entrance Part Lighting The entrance part lighting shall be as follows.

(1) The road surface luminance of boundary part shall be the value set up by taking in consideration the appearing frequency in a year of luminance in access zone defined by the state of visual field of operator in the neighborhood of tunnel entrance multiplied with coefficient defined by the design speed.

(2) The road surface luminance of transition part and relaxing part shall be decreased according to the distance from entrance of tunnel taking the road surface luminance of boundary part as 100 % as shown in Fig. 3 so as to be connected smoothly with the value of road surface luminance of fundamental part lighting.

(3) The road surface luminance of entrance part lighting is desirable to be adjusted according to the variation of luminance in access zone by season, weather and time.

(4) The road surface luminance of entrance part lighting may be increased or decreased according to traffic state.

(5) As to the value to be set by appearing frequency in a year of luminance in access zone determined by the visual state of operator Fig. 2 shall be taken as the standard.

(6) The coefficient of multiplication to determine the value of road surface luminance of boundary part is desirable to comply with Table 3.

(7) The luminance of wall surface of entrance part lighting is desirable to be the value of 1.5 times or over the value of road surface luminance at the position.

Fig. 3. Road Surface Luminance of Tunnel Entrance Part

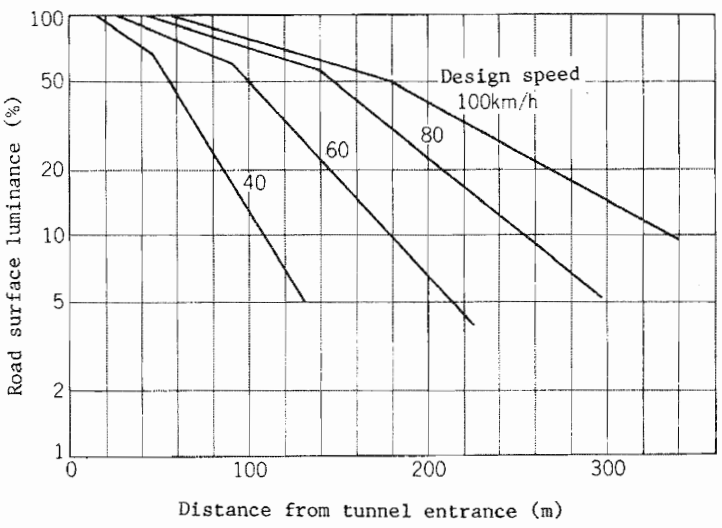


Table 2. Luminance in Access Zone to Be Set

Design speed km/h	Rate of sky occupying in 20 degrees visual field** %							
	20 min.		20 to 10		10 to 5		Under 5	
	State of circumference Unit cd/m²							
	Bright	Ordinary	Bright	Ordinary	Bright	Ordinary	Bright	Ordinary
100	6 000	5 000	5 000	3 000	4 000	2 500	4 000	2 000
80								
60	5 000	4 000	4 000	2 500	3 000	2 000	3 000	1 500
40								

Note** This visual field means that which the operator in front by visual range of tunnel entrance looks at the tunnel.

Remarks 1. That the state of circumference is bright means the case where the natural features on the earth near to the tunnel entrance are white, grey etc. and high in reflectivity and the case where the state of snow continues for long period in the neighborhood of entrance is included.

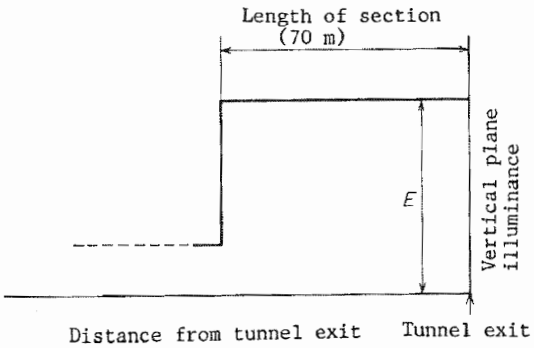
2. That the state of circumference is ordinary means the case except the above.

Table 3. Coefficient to Be Multiplied with Luminance in Access Zone

Design speed km/h	Coefficient
100	0.07
80	0.05
60	0.04
40	0.03

6.3 Exit Part Lighting The exit part lighting shall, in general, give the vertical plane illuminance of value $\frac{1}{10}$ or over of the value of luminance in access zone measured through exit part from inner part of tunnel over 70 m from inner part of tunnel to its exit as shown in Fig. 4.

Fig. 4. Tunnel Exit Part Lighting



6.4 Lighting of Connected Roads of Tunnel The reference of road lighting to be set in the night in the sections near to the entrance and exit of tunnel of connected roads of tunnel shall, in general, comply with JIS Z 9111.

7. Maintenance and Control

The lighting facilities of tunnel are desirable to be controlled and maintained adequately by taking attention to the following items so as not to generate the stop of function, etc. by the deterioration of characteristic and stain, life and breakage, etc. of lamps and lighting apparatus accompanying the use.

(1) Burning state

(2) Mounting state of lighting apparatus and automatic dimmer

(3) Stained state of lighting apparatus

(4) Luminance or illuminance of road surface and wall surface

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